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PALEONTOLOGICAL INVENTORY & ASSESSMENT NORTHERN PORTION OF THE ROYAL GORGE RESOURCE AREA, CENTRAL COLORADO

BUREAU OF LAND MANAGEMENT
CAÑON CITY, COLORADO
DENNIS W. FISCHER 12/20/79

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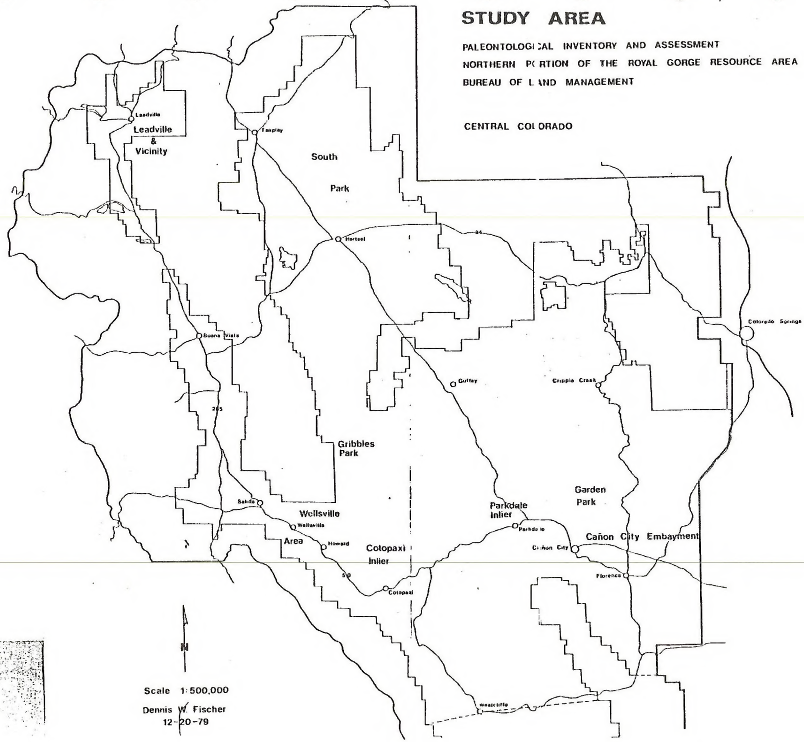
STUDY AREA

PALEONTOLOGICAL INVENTORY AND ASSESSMENT
NORTHERN PORTION OF THE ROYAL GORGE RESOURCE AREA
BUREAU OF LAND MANAGEMENT

CENTRAL COLORADO



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Dennis W. Fischer
12-20-79

INTRODUCTION

This report is the result of the Bureau of Land Management (BLM) contract No. CO-050-PH9-236 to provide a paleontological inventory and assessment of the northern portion of the Royal Gorge Resource Area (Index Map). Work commenced on July 16, 1979 and is completed as of this date, December 20, 1979. Approximately 16 days were expended in field checking of various localities within the study area in an attempt to ascertain the relationship of BLM land to known fossiliferous formations and to locate new fossil occurrences.

Pre-work conferences with representatives of the BLM clarified the objectives of the study, these being that the study is to be used primarily for planning purposes. The utility of the study, I hope will be to foresee, assess, and possibly mitigate land use conflicts arising where fossils of high scientific interest or uniqueness are subject to irrevocable loss.

The information in this report is contained mostly within the tables and appended maps. All of the references to various genera and species made in the text and lists are reported as they appear in their original taxonomic nomenclature. No attempt is made here to revise or otherwise improve the taxonomy. Many references have been included which do not specifically pertain to the study area yet are considered important because they suggest what fossils may also be found in the study area, but have simply not been reported.

I would like to acknowledge the very kind assistance provided by Mr. Howard Wertsbaugh and Mr. John Beardsley of the BLM in aspects of project planning and review. For his unmeasurable help in compiling references and localities and his thoughtful discussions, I am sincerely grateful to Dr. William A. Fischer. For the information and recommendations contained herein, however, I am solely responsible.

BASIS OF LAND CLASSIFICATION

Specification for BLM land classification were written for this study as follows:

Class 1. "Immediate detailed study followup is needed. Fossils of scientific interest are exposed on the surface or are very likely to be discovered with detailed field work in the area."

Class 2. "There is evidence of fossils; but the presence of fossils of scientific value has not been established, and is not anticipated. Detailed study may be desirable in the future for the evaluation of all types of fossil collecting. This classification may be used to identify recreational values in fossils."

Several formations within the study area contain fossils that are of a higher scientific interest. A slightly more broad interpretation of Class 1, than in the specifications, is taken to include formations that for various and different reasons are important. It is beyond the scope of this study to be able to categorically say that critical fossils are exposed and immediate detailed study is needed. What is suggested, however, is that when vertebrate fossils, in particular, occur in these formations, they may or may not have had adequate study but by nature are rather scarce. Some of these formations are either very thick or extensive, and it would be highly desirable to delineate the area more specifically. At this stage of work, the entire formation where applicable must be considered as bearing a certain probability of yielding material similar to what has been reported to date.

STRATIGRAPHIC SECTION FOR SOUTH PARK AREAS

Tertiary	Trump Formation
	Wagontongue Formation
	Antero Formation
	Balfour Formation
	Denver Formation
Cretaceous	Laramie Formation
	Fox Hills Sandstone
	Pierre Shale
	Niobrara Formation
	Benton Shale
	Dakota Sandstone
Jurassic	Morrison Formation
	Garo Sandstone
Permian - Penn.	Maroon Formation
	Weber Formation
Mississippian	Leadville Limestone
	Chaffee Group
Miss.? - Devonian	Dyer Formation
	Parting Formation
Cambrian	Peerless Dolomite
	Sawatch Quartzite
	Precambrian rocks

SOUTH PARK AREAS

Formations of Cambrian to Recent age outcrop in various portions of the South Park and vicinity. Pre-Pennsylvanian rocks are restricted to the extreme western margin of the Park, actually on the flanks of the Mosquito Range. A nearly complete pre-Pennsylvanian section is exposed about three miles southwest of Trout Creek Pass. A discussion of fossil occurrences in these formations can be found in the Wellsville, Leadville, and Canon City Embayment descriptions and related tables.

Weber Formation (Pennsylvanian)

The Weber Formation, with a variable lithology, is generally described by Stark et.al. (1949, p.35) as having a lower member largely composed of dark grey shales with interbedded limestones and sandstones, and an upper member which is an arkosic conglomerate with shale and sandstone.

The Weber is substantially fossiliferous and has produced large, well-preserved collections of marine invertebrates and plants. Johnson (1934, p. 31-33) lists a prodigious fauna for localities ranging from northwest of Alma to Trout Creek.(Table 1) Although many species on the list are described as new, a majority of the elements is common and well-known. Phyllopod crustacean remains are noted by Johnson and Gould (1933).

Several collections also made in the Mosquito Range exhibit a typical Pennsylvanian flora with specimens noted as being well-preserved (Read 1934, p.79-91)(Table 2). As with the invertebrates, the elements of the flora are common and well-known. Fossil wood from the lower member is abundant in sec. 29, 33, and 34, of T13S, R77W (Stark and others 1949).

Other fossil material discovered in the Weber includes algae (Table 3) and certain indications of fish. Scarce fish vertebra, ganoid scales, and abundant coprolites all attributed to Paleoniscus (Paleontiscus) are found in black shales from the upper portion of the formation (Johnson 1934).

Maroon Formation (Permian)

The Maroon Formation as exposed in western South Park is typically red beds composed of siltstones and sandstones and bears an aggregate thickness of over 8,000 feet.

A highly significant collection of fossil insects has come from the Maroon at a locality known as the Nelson Ranch, about 4 miles southeast of Fairplay. These insects described by Scudder (1890) (Table 4) are considered to be some of the most important Permian insects of North America. Associated with the insects are also very fine botanical fossils of a diverse flora (White 1912) (Table 5).

Apparently no BLM lands are in immediate association with the Nelson Ranch locality. However, adjacent BLM land does cover areas of Maroon outcrop and in consideration of these fossil occurrences, they are given a somewhat higher importance.

A sparse marine invertebrate fauna (Table 6) dominated by brachiopods is described by Stark and others (1949, p.45) and by Girty (1903) (Table 9, in part). Indications of vertebrates is only by a slab containing small footprints (Stark and others 1949). Silicified wood and lime-secreting algae are reported at several localities.

Morrison Formation (Upper Jurassic)

In South Park, Jurassic strata are represented by the Garo and Morrison Formations. Both have a limited areal extent and are essentially confined to narrow exposures along the central hogbacks. The Garo is not known to be fossil-bearing; and while the Morrison is noted for its vertebrates elsewhere, only indeterminable bone fragments are found in this region.

Variegated shales with thin lacustrine limestones and channel sandstones typically make up the formation.

Two species of fresh-water gastropods are cited by Yen (1952, p.32) as coming from Red Hill Gap, about 4½ miles northeast of Fairplay. A more extensive non-marine invertebrate fauna including these species occurs in the Morrison of Garden Park and other areas (Table 18). It might be predicted that with additional work, a similar fauna with associated ostracods and charophytes could be derived. These interesting bivalves and gastropods have received only summarial study and may be of value in reconstructing paleoenvironments of the Morrison.

The Morrison Formation in South Park is not given a "higher" classification, as it is in Garden Park, because it has more limited extent and the presence of highly important discoveries has not been demonstrated.

Dakota Sandstone (Lower Cretaceous)

The sandstones of the Dakota have essentially the same limited distribution as does the Morrison. The only fossil occurrences reported for South Park are the cone, Pinus quenstedti, and poorly-preserved leaves and stems of plants (Stark and others 1949, p.51). Other portions of the study area and the region yield both invertebrate and vertebrates, as well as, additional plant fossils. The Dakota Sandstone in South Park can be expected to contain at least some of these other fossils.

Benton Group (Upper Cretaceous)

The Benton Group in the area is represented by a section of black shales. Their areal distribution is somewhat greater than that for the Morrison and the Dakota. In their collection, Stark and others (1949, p.52) list a typical and well-known marine invertebrate assemblage from the formation, noting that the fossils are numerous in sandy, upper beds. Ostrea lugubris and species of Inoceramus are the common forms. Fragments of fish teeth and bones, as well as, shark teeth are also recognized.

Niobrara Formation (Upper Cretaceous)

The Niobrara Formation is not very fossiliferous in the South Park area. Typical marine elements are also species of Ostrea and Inoceramus. Foraminifera are abundant in the upper shales, and fish are indicated by miscellaneous scales, bones, and teeth at various horizons and localities. (Stark and others 1949, p.54)

Pierre Shale (Upper Cretaceous)

The Pierre Shale outcrops over large areas of South Park. Approximately 2,500 feet of black shales comprise the section. Fossils apparently are abundant in occasional calcareous and ironstone concretions, similar to Front Range occurrences. Stark and others (1949) report a collection from about 2 miles west of Como containing familiar forms of cephalopods and bivalves (Table A). A locality at Trout Creek, nearby, yields both fragments of crustaceans and coprolites. Tepee Butte type structures with their diagnostic assemblages are not recognized.

Fox Hills Sandstone (Upper Cretaceous)

Fossil occurrences in the Fox Hills are limited to infrequent and non-indicative marine bivalves and gastropods (Table A). The fine-grained sandstones have a restricted outcrop area, although somewhat larger than those for the other Cretaceous formations, excepting the Pierre.

Laramie Formation (Upper Cretaceous)

The Larmie Formation is poorly exposed in South Park and confined to the northern reaches of the area. The formation consists largely of sandstone and shale with minor coal and volcanic tuff occurring. A minor flora composed of Aneimia sp. cf. elongata, Celastrus? gaudini, a palm, and a monocotyledonous? grass is present. (Stark and others 1949, p.52) (Table A).

Denver Formation (Tertiary - Eocene)

Denver Formation outcrops cover extensive areas of eastern South Park. The unit is very thick, estimated to be at least 8,000 feet, is highly conglomeratic, and does contain some volcanic tuffs. Good plant specimens, however, are described by Knowlton (1930) (Table A). Actual logs and stumps of silicified wood are reported by Stark and others (1949).

Balfour Formation (Oligocene?)

Marking the first occurrence stratigraphically of Tertiary lake bed strata, the Balfour is found in limited areas of the southeastern region of the Park. No fossils are reported; however, given the nature of the formation, fossils are probable.

Antero Formation (Oligocene)

The deposits of paleolake Antero are possibly the most significant, paleontologically, of all sedimentary strata exposed in the South Park area. Fossil mammals, wood, leaves and seeds, algae, fresh-water gastropods and ostracods, as well as, insects have all been discovered.

Lithologically, the Antero beds are a complex set of conglomerates, limestones, sandstones, and "paper shales" of water-laid tuffs - all deposited in various portions of the lake basin according to expansion and contraction of paleolake Antero. The general depocenter occupies the western third of the Park. Outcrops range from near Fairplay in the north to nearly Gribbles Park in the south.

A collection of mammalian teeth, fragmentary jaws, and limb bones has been made at several localities and is briefly described by Stark and others (1949, p.66). (Table A) The fauna contains elements of the Perissodactyls as Mesohippus, a small equid; also a Titanothere, and several rhinoceras and rhinoceratoid types including Trigonias, Hyracodon, and Caenopus. Among the Artiodactyls are the camel-like Agrichoerus and Leptomeryx. Other elements include the diminutive Hypisodus, also a Hypertragulid, and Paleolagus, a hare.

Insects, gastropods, and plants collected from the Antero have affinities for those found at Florissant. Stark and others (1949, p.66) cite "an exceptionally rich gastropod locality" in the SW¼ of sec. 27, T12S, R76W, containing common fresh-water forms along with ostracods (Table A). If correctly located, this occurrence involves BLM land and might suggest a site for public collection with ample access.

Fossil leaves and silicified wood are common in the beds.

Collections of botanical specimens from two localities are reviewed by Durden (1966) and by Stark and others (1949). The forms are all common.

Over 400 specimens of diverse fossil insects have been recovered by Durden in the Chase Basin area of eastern South Park.(Table 7) These remarkable occurrences are surprisingly little-known and Durden suggests that additional work should yield a fauna "as rich as that of Florissant". BLM lands are apparently not directly involved with Durden's localities, however, portions of these "paper shale" facies are covered by BLM land.

Based on the foregoing, the Antero Formation is considered highly significant, and is designated as Class 1 on the land classification maps. Many areas of Antero outcrop on BLM lands, however, may in certain cases be covered by alluvial and glacial deposits. Follow-up work would definitely be of benefit to ascertain fossil occurrences on BLM land.

Wagontongue and Trump Formations (Miocene and Pliocene?)

Of the Wagontongue and Trump Formations, only the Wagontongue has produced fossil material. A "perfect jaw with teeth" of an equid is reported by Stark and others (1949, p.69), however, it along with other unidentified fragmentary bones, teeth, and wood are suspect of having been reworked from the Antero Formation.

In summary, the South Park region contains numerous fossiliferous formations. Among these, the Maroon is significant as an important source of Permian age insects and large numbers of marine invertebrates, and the Antero is important due to its mammals and insects.

The Antero is considered to be Class 1 and all other fossil-bearing formations as Class 2. Few localities cited in the literature actually correspond to BLM land. However, many areas of BLM land offer possible locations for public collection without undue detriment to further scientific study. Additional work is neccessary to determine abundance and quality of preservation of fossils and the accessibility of a given site. References to much of the "petrified wood" that occurs in many places, perhaps should be avoided.

Table A Fossil

Locat
"near the head o Creek" sec. 17,
Sec. 29, 33, 34,
Secs. 6, 11, 21, Secs. 10, 22, T.
T. 9S, R. 77W.
SE¼ sec. 7, T. 1
NE¼ sec. 7, T. 1
SE corner sec. 2
"Nelson Ranch, n southeast of Fai
"Nelson Ranch, n southeast of Fai
"near Fairplay c highway east of localities betwe and Antero reser
Sec. 32, T. 12S.

Table A   Fossil collecting localities in the South Park portion of the BLM Canon City District.

Location	Author-Reference	Formation-Geologic Age	Depository	Fossils
"near the head of Pennsylvania Creek" sec. 17, T. 9S, R. 78W.	Stark, J. T., et al. (1949, p. 38)	Weber-Pennsylvanian		"well-preserved fossil plants" Neuropteris, Cordaites Sphenopteris, Stigmaria
Sec. 29, 33, 34, T. 13S., R. 77W.	Stark, J. T., et al. (1949, p. 41)	Weber-Pennsylvanian		"abundant fossil wood"
Secs. 6, 11, 21, 22 T. 13S., R. 77W. Secs. 10, 22, T. 11S., R. 78W.	Johnson, J. H. (1940)	Weber-Pennsylvanian	Colorado School of Mines and U.S. National Museum	New species of algal stromatolites
T. 9S, R. 77W.	Stark, J. T., et al. (1949, p. 45)	Maroon-Permian		Abundant marine invertebrates
SE¼ sec. 7, T. 12S., R. 75W.	Stark, J. T., et al. (1949, p. 45)	Maroon-Permian		Marine invertebrates
NE¼ sec. 7, T. 12S., R. 75W.	Stark, J. T., et al. (1949, p. 45)	Maroon-Permian		Abundant crinoid columnals
SE corner sec. 25, T. 12S., R. 76W.	Stark, J. T., et al. (1949, p. 45)	Maroon-Permian		Marine invertebrates
"Nelson Ranch, nearly 4 miles southeast of Fairplay"	Scudder, Samuel H. (1890, p. 457)	Maroon-Permian (described as Triassic)	U.S. National Museum	21 species Permian insects
"Nelson Ranch, nearly 4 miles southeast of Fairplay"	White, David (1912)	Maroon-Permian (described as Triassic)	U.S. National Museum	24 species of Permian plants "beautifully preserved"
"near Fairplay cemetary and along highway east of town--many localities between Fairplay and Antero reservoir"	Stark, J. T., et al. (1949, p. 46)	Maroon-Permian		"lime-secreting algae"
Sec. 32, T. 12S., R. 77W.	Stark, J. T., et al. (1949, p. 46)	Maroon-Permian Division 3 of Pony Spring member		"a slab containing small vertebrate footprints"

Table A Page 2

Location	Author-Reference	Formation-Geologic Age	Depository	Fossils
Sec. 11, T. 12S., R. 74W.	Stark, J. T., et al. (1949, p. 52)	Greenhorn & Carlile Members of Benton-Cretaceous		Inoceramus Ostrea Gryphea Scaphites
"2 miles west of Como"	Stark, J. T., et al. (1949, p. 55)	Pierre Formation-Cretaceous		Scaphites Hemiaster Dentalium Inoceramus Baculites
Secs. 2, 11 T. 9S., R. 75W.	Stark, J. T., et al. (1949, p. 56)	Fox Hills-Cretaceous		Halymenites Nucula Pteria Ostrea Dentalium Cinulia Cardium Dosiniopsis Tellina Nactra Pyrifusus
S.E. corner sec. 1, T. 10S., R. 75W.	Stark, J. T., et al. (1949, p. 59)	Denver-Eocene		Woodwardia Populus Ficus Platanus Allantodiopsis Quercus Juglans
"6 miles south of Como"	Stark, J. T., et al.	Denver-Eocene		Allantodiopsis Juglans Populus Ficus Platanus Cissus Cornus
SW¼ sec. 8, T. 14S., R. 75W.	Stark, J. T., et al. (1949, p. 66)	Antero-Oligocene	U.S.National Museum	Mesohippus Hyracodon Agriochoerus Trigonias Caenopus?

Location	Author-Reference	Formation-Geologic Age	Depository	Fossils
Sec. 8, T. 15S., R. 75W.	Stark, J. T., *et al.* (1949, p. 66)	Antero-Oligocene	U.S.National Museum	*Hypisodus* *Palaeolagus*
Sec. 22, T. 10S., R. 76W.	Stark, J. T., *et al.* (1949, p. 66)	Antero-Oligocene	U.S. National Museum	*Palaeolagus* *Leptomeryx*
SW¼ sec. 27, T. 12S., R. 76W.	Stark, J. T., *et al.* (1949, p. 66)	Antero-Oligocene		"an exceptionally rich gastropod locality" *Lymnaea* *Polygyra?* *Gonyodiscus* *Valvata* *Pseudosuccinea* also--"fresh-water ostracod carapaces common"
SW¼ sec. 1, T. 10S., R. 75W.	Stark, J. T. *et al.* (1949, p. 67)	Antero-Oligocene		Silicified wood of *Pinus* *Quercus* & *Ulmus* Leaves and seeds of *Quercus* *Cercocarpus*, *Artemisia?*, and *Pinus*
Secs. 29, 30 T. 14S., R. 75W. NW¼ sec. 6, T. 15S., R. 75W.	Stark, J. T. *et al.* (1949, p. 69)	Wagontongue-Miocene, Pliocene		"one perfect jaw with teeth, a species of equid of upper Miocen or lower Pliocene age"

Table 1.

SPECIES LIST - WEBER FORMATION - MOSQUITO RANGE FROM NORTHWEST OF ALMA TO TROUT CREEK JOHNSON (1934)

Corals:

Amplexus zaphrentiformis
Lophophyllum profundum
L. profundum var. *sauridens*
L. sp.?

Echinoderms:

Archaeocidaris sp.?
A. cratis
Echinocrinus sp.?
Crinoid stems

Bryozoans:

Fenestella sp.?
Fistulipora sp.?
Polypora sp.?
Rhombopora lepidodendroides
Septopora sp.?
Stenopora sp.?

Brachiopods:

Chonetes geinitzianus?
C. aff. *C. geinitzianus*
C. sp.?
Cleiothyridina pecosi
C. pecosi var.
Composita subtilita
C. sp.?
Derbya crassa
Lingula carbonaria
Lingula sp.?
Marginifera ingrata
M. ingrata var.
Marginifera muricata
M. sp.?
Orbiculoidea missouriensis
O. sp.?
Productus coloradoensis
P. cora
P. cora var. *nodosus*
P. aff. *P. pertenius*
P. n.sp. aff *P. semistriatus*
P. sp.?
Pustula nebraskensis
P. nebraskensis var.
Pustula n.sp.
Spirifer opimus
S. opimus var. *occidentalis*
S. opimus var.
S. rockymontanus
S. sp.
Squamularia perplexa?
S. sp.
Strophalosia spondyliformis

SPECIES LIST - WEBER FORMATION - continued

Bivalvia:

Aviculipecten scalaris
Deltopecten occidentalis
D. aff. *D. scalaris*
D. sp.
Edmondia sp.?
Leda n.sp.
Leda sp.?
Lima sp.?
Myalina perniformis
Nucula sp.?
Pleurophorus subcostatus?
Schizodus sp.?
Yolida glabra

Gastropods:

Aclisina (4 n.sp.)
Bellerophon crassus
B. n.sp.
B. sp.?
Bucanopsis sp.?
Bulimorpha sp.?
B. n.sp.
Cyclonema n.sp.
Enchostoma sp.?
Euomphalus (4 n.sp.)
Euphemus carbonarius
E. nodicarinatus?
Gastropod fragments
Goniospira sp.?
Meekospira sp.?
Microdoma (2 n.sp.)
Naticopsis (5 n.sp.)
Othonema? sp.?
Patellostium n.sp.
P. sp.?
Phanerotrema grayvillense
Pharkidonotus percarinatus
Placunopsis sp.
Plagioglypta sp.?
Pleurotomaria (2 n.sp.)
P. sp.?
Schizostoma catilloides
Sphaerodoma primigenia
S. sp.?
Trachydomia (2 n.sp.)
Zygopleura sp.?
Conularia crustula
Dentalium sp.?

Cephalopods:

Goniatites sp.?
Othoceras sp.?
Protocycloceras sp.?

SPECIES LIST - WEBER FORMATION - continued

Crustaceans:

Estheria aff. *E. ortoni*
Phillipsia sp.?
Trilobite fragment

Vertebrates:

Coprolites
Fish tooth

Table 2.

PLANT FOSSILS - WEBER FORMATION - SOUTH PARK & VICINITY STARK AND OTHERS (1949)

Localities: near the head of Pennsylvania Creek, about 85 feet above the base.

about 2 miles west of Evans Peak - 170 feet above the base.

Stigmaria verrucosa
Neuropteris dluhoschi
N. heterophylla
N. cf. *gigantea*
Sphenopteris asplenioides
S. cf. *microcarpa*
S. cheathami
Cordaites sp.
Calamites sp.
Asterophyllites longifolius
Diplotmema patentissima
Adiantites rockymontanus
Cordaianthus sp.
Cordaicarpon sp.
Trichopitys whitei
Dactylophyllum johnsoni
Fossil wood

Table 3.

JOHNSON (1940) FOSSIL ALGAE (all new species)

Shermanophycus gouldi
Gouldiana carbonaria
G. magna
Leptophycus gracilis
Stylophucus carbonarius
S. calcarius
Artophycus columnarius
Cryptozoon coloradensis
Calyptophycus verrucius
Girvanell sp.?

Table 4.

FOSSIL INSECTS AND PLANTS - MAROON FORMATION - SOUTH PARK AREAS (NELSON RANCH) STARK AND OTHERS (1949)

Locality: about 4 miles southeast of Fairplay (the Nelson Ranch) Scudder (1890) - all new species.

INSECTS:

Etoblattina persistens
E. sp.
Spiloblattina gardineri
S. triassica
S. guttata
S. marginata
Anthracoblattina triassica
Petrablattina sequa
P. meieri
Poroblattina arcuata
P. lakesii
Neorthroblattina albolineata
N. lakesii
N. rotundata
N. attentuata
Scutinoblattina brongniarti
S. intermedia
S. recta
Cerophyllis justiciae
C. delicatula
C. adolescens

Table 5.

PLANTS: same locality - White (1912)

Sphenopteris schimperiana?
S. lebachensis
S. dentata
S. gutzholdi
Pecopteris pinnatifida
P. foeminaeformis
P. (*Danaeites*) sp.
Scolecopteris elegans
Callipteris cf. *hymenophylloides*
C. cf. *lyratifolia*
Odontopteris subcrenulata
Neuropteris auriculata
Calamites kutorgae?
Sphenophyllum obovatum
Sigillaria? sp.
Sibillariostrobus hastatus
Poacordaites sp.
Walchia piniformis
W. hypnoides
W. gracilis?
Ulmannia sp.
Voltzia sp.
Araucarites sp.
Gomphostrobus bifidus

Table 6.

SPECIES LIST - MARRON FORMATION - SOUTH PARK AREAS
STARK AND OTHERS (1949)

Invertebrates:

from T9S, R77W

- Crinoid stems
- *Polypora* sp.?
- *Productus* sp.? (fragments)
- *Composita* sp.?

from the S.E¼, sec. 7, T12S, R.75W

- *Polypora* sp.?
- *Composita* sp.
- *Dielasma* sp.
- *Spirifer* sp.
- *Productus*
- Internal casts of a gastropod - Bellerophon)
- Abundant crinoid stems

from the N.E.¼, sec. 25, T12S, R76W

- Crinoid stems
- *Composita* sp.?
- *Squamularia* sp.?
- *Spirifer* cf. *triplicatus*
- *Productus* (fragments of *P. semireticularis* type)
- Gastropods (internal casts of several types)

FOSSIL INSECTS AND PLANTS - ANTERO FORMATION, SOUTH PARK REGION DURDEN (1966)

Plant Fossils: The locality is described as being in Chase Basin.

Sequoia affinis

Chamaecyparis linguaefolia

Salix spp.

Bidens sp.

Betula sp.?

Pinus florissanti

P. wheeleri

Pinus sp.

Quercus predayana

Mahonia marginata

Cardiospermum terminalis?

Picea cf. *P. magna*

Abies or *Pseudotsuga sp.*

Insect Fossils: The locality is Chase Basin Yale Peabody Museum No. E-201 (2500 feet south on the Elkhorn Road, from the northwest corner post of sec. 7, T11S, R74W, Park County, Colorado).

N.B. over 400 fossil insect specimens were collected at this locality.

Diptera

Syriphidae, Tipulidae, and pupal exuviae

Hemiptera

Corixidae, other Heteroptera, and Homoptera

Psocoptera

43 un-named specimens

Hymenoptera

Symphyta, Formicidae, Ichneumonidae, Chalcidae?, Apoidea, and others.

Coleoptera

Staphylinidae and others

Ephemerida

3 un-named specimens

FOSSIL INSECTS AND PLANTS - ANTERO FORMATION - continued

Neuroptera
    Chrysopidae

Mecoptera?
    2 un-named specimens

Araneida
    1 un-named specimen

STRATIGRAPHIC SECTION FOR LEADVILLE AND VICINITY

Pennsylvanian	Minturn Formation
	Belden Formation
Miss.	Leadville Limestone
Chaffee Group	
Devonian	Gilman Sandstone
	Dyer Dolomite
	Parting Formation
Cambrian	Peerless Formation
	Sawatch Quartzite
	Precambrian rocks

LEADVILLE AND VICINITY

Rocks of Cambrian through Pennsylvanian age are exposed in portions of the Leadville region and Ten-Mile Mountains. Although extensive faunas are contained in certain formations, no areas are considered to be of a high priority.

The Leadville Limestone is primarily the only unit for which species lists have been compiled. In an older report, Girty (1903) describes a typical marine invertebrate fauna for the Leadville (Table 9) and a grouping of the Weber, "Robinson", and Maroon Formations (Table 8). The assemblage is dominated by brachiopods and gastropods. Echinoderms, bryozoa, bivalves, crustaceans, and cephalopods are also present. All are relatively common forms.

The quality of fossil preservation is variable in the district. Many areas have been substantially altered by ingneous activity, sometimes with attendant destruction of fossil material. Many good specimens can be collected; however, with all of their mention, most specimens are indeterminable masses, highly replaced by silica in chert nodules and layers.

Fossil algae are abundant. Johnson (1945) cites nine different species from the formation (Table 11). Foraminifera are probably also abundant, and have been used to help date the Leadville (Hillgarth and Skipp 1962) (Table 10).

The marine invertebrate assemblage found in Table 1 , described by Johnson (1934), for the Weber Formation is applicable to much of the Leadville region. The botanical locality cited in Read (1934) as being two miles west of Evans Peak might be considered a part of the district, and similar occurrences might be expected in the outcrop areas of the Weber, locally.

SPECIES LIST - WEBER, ROBINSON LIMESTONE, AND MAROON FORMATIONS, LEADVILLE AND TENMILE DISTRICTS
GIRTY (1903)

Echinodermata:	*Archaeocideris cratis*
	A. ornata
	A. trudifer?
Bryozoa:	*Rhombopora lepidodendroides*
	Fenestella sp.
	Polypora cf. *distincta*
	P. Whitei var. *insculpta*
	Septopora delicatula
	S. cestriensis
Brachiopoda:	*Lingula carbonaria*
	Orbiculoidea manhattanensis
	Rhipidomella pecosi
	Derbya crassa
	Meekella striaticostata
	Chonetes geinitzianus
	Productus semireticulatus var. *hermosanus*
	P. inflatus
	Marginifera ingrata
	Spirifer rockymontanus
	Squamularia perplexa
	Seminula subtilita
	Lingula tighti
	Spirifer boonensis?
Bivalvia:	*Aviculopecten rectilaterarius*
	A. carboniferous
	Myalina wyomingensis
	Aviculopinna? *peracuta*
	Nucula ventricosa?

- continued -

SPECIES LIST - WEBER, ROBINSON LIMESTONE, AND MAROON FORMATIONS - continued

Bivalvia	*Nucula* indet.
	Entolium? sp.
	Macrodon *obsoletus*
	M. *tenuistriatus*?
	Pleurophorus *occidentalis*?
Gastropoda:	*Euconispira* *taggarti*
	Phanerotrema cf. *grayvillense*
	Worthenia? *marcoviana*?
	Loxonema sp.
	Worthenia? sp.A
	Strophostylus *remex*
	Bulimorpha *chrysalis*
	Bellerophon *crassus*
	B. *pericarinatus*?
	B. sp. indet.
	Patellostium *montfortianum*
	minute gastropods
Arthropoda: Crustacea	*Beyrichia* sp.
	Leperditia sp.
	Bairdia cf. *cestriensis*
	Kirkbya *sp*.
	Phillipsia *trinucleata*
Cephalopoda:	*Domatoceras* sp.

Table 9.

SPECIES LIST - LEADVILLE LIMESTONE
GIRTY (1903)

LEADVILLE AND VICINITY

Coelenterata: *Zaphrentis*? sp.B

Brachiopoda: *Orthothetes inaequalis*
Spirifer sp.A and sp. B
Seminula subquadrata?
Eumetria woosteri

Bivalvia: *Myalina arkansasana*?
Conocardium sp.

Gastropoda: *Straparollus* cf. *spergenensis*

Listed by R.P.Whitfield *in* Girty (1903):

Euomphalus sp. cf. *E. spergenensis*
Spiriferina sp.
Athyris subtilita
Pleurophorus oblongus
Productus costatus
Spirifera rockymontana
S. (*Martinia*) *lineata*
Streptorhyncus crassus (*crenistria*)
Cyathophylloid corals resembling *Zaphrentis* or *Cyathaxonia cynodon*

FORMATION EQUIVALENTS AT WELLSVILLE AND AT CANYON CITY AND VICINITY

Coelenterata: *Syringopora aculeata*
S. surcularia

Brachiopoda: *Spirifer centronatus*
Seminula claytoni
Orthothetes inaequalis
Spiriferina solidirostris?

Table 9.(page 2) & 10.

SPECIES LIST - LEADVILLE LIMESTONE - continued

Brachiopoda
Cranaena subelliptica var. *hardingensis*

Bivalvia: *Myalina arkansasana*?

Gastropoda: *Pleurotomaria*? sp.A

Table 10.

Foraminifera: Hillgarth and Skipp (1962)

Plectogyra tumula
Endothyra aff. *E. scitula* (*E. symmetrica* Zeller)
Septaglomospiranella sp.

by communication from N.W.Bass and S.A.Northrop in Hilgarth and Skipp (1962)
- *Eumetria verneuiliana*

Table II.

FOSSIL ALGAE - LEADVILLE LIMESTONE
JOHNSON (1945) UPPER LEADVILLE LIMESTONE, ASPEN, GLENWOOD SPRINGS, AND LEADVILLE AREAS

Rhodophyceae:	*Solenopora similis*
	S. glenwoodensis
Chlorophyta:	*Coelosporella sp.*
	Garwoodia aff. *gregaria*
	G. media
	Ortonella furcata
	O. cf. *kershopensis*
	O. coloradoensis
Cyanophyta:	*Girvanella? nicholsoni*
	the Spongiostroma family

STRATIGRAPHIC SECTION FOR WELLSVILLE AND ADJACENT AREAS

Tertiary	Dry Union
Permian – Penn.	Sangre de Cristo Formation
	Minturn Formation
	Belden Formation
Miss.	Leadville Formation
	Chaffee Group
Devonian	Dyer Dolomite
	Parting Quartzite
Ordovician	Fremont Formation
	Harding Sandstone
	Manitou Limestone
	Precambrian rocks

WELLSVILLE, HOWARD, COTOPAXI INLIER, AND GRIBBLES PARK AREAS

Rocks of Cambrian through Permian age are exposed in various areas surrounding the towns of Wellsville and Howard, and in the Gribbles Park and Cotopaxi Inlier regions. Small areas of Tertiary rocks are found immediately west of Howard and northwest of Wellsville. Significant fossil occurrences have been discovered in the Fremont Formation, the Chaffee Group, the Sangre de Cristo Formation, and the Dry Union Formation.

Harding Formation (Middle Ordovician)

The Harding in the Canon City area contains a highly important fauna. (see Table B) Some elements of this fauna are found in outcrop areas in the western part of the Cotopaxi Inlier. Many specimens of Dictyorhabdus, a problematic - supposedly colonial organism, have been found there (W.A.Fischer oral communication). Phosphatic plates of dermal armor from Ostracoderm fish are common. The Harding is not considered Class 1 in these areas, as opposed to the Canon City Embayment and environs.

Fremont Dolomite (Upper Ordovician)

Excellent exposures of the Fremont occur in the vicinity of Spring Gulch near Wellsville and along the western margin of the Cotopaxi Inlier. Sweet (1961) reports a collection from the Spring Gulch locality containing: Saffordophyllum, Receptaculites, Calapoecia, and Streptelasma (Table B). No localities are reported from the Inlier, and field checking produced none of significance. Additional elements of the type of fauna seen in the Fremont at Canon City could be expected to also occur in these areas, however, the formation is still considered Class 2 for this region.

Chaffee Group

Dyer Dolomite and Parting Formation (Lower Mississippian and Upper Devonian)

Two important collections of fossil fish remains have been made in the Chaffee Group at the Spring Creek locality and at Gribbles Park. Pampe (1969) reports 13 specimens of disarticulated remains attributed to the Placoderm, Bothriolepis and the Rhipidistian, Holoptychius (Table 12). The collection was made from a red siltstone - dolomite, about 30 feet above the base of the Parting Formation ("Chaffee Formation"). The specimens are deposited at the University of Nebraska State Museum.

Bothriolepis and Holoptychius, both apparently freshwater dwellers, are common and well-known Devonian fish with a world-wide distribution. Bothriolepis is a diminutive form, while Holoptychius may obtain a length of several feet, and its general group (the Sarcopterygii) is the lobe-finned stock that eventually gave rise to land vertebrates. Both disappear at the end of the Devonian.

section for the "Chaffee Formation", designated by Kirk (1931) and further defined by Reeves (1962) as the north side of Spring Gulch, sec. 13, T49N, R9E, Fremont County.

Leadville Limestone (Lower Mississippian)

The Leadville Limestone is fossiliferous in the region. A composite list (Table 9) from Girty (1903) shows a fauna composed of familiar corals, brachiopods, bivalves, and gastropods. No specific locations are mentioned. Quality of preservation is unknown.

Belden and Minturn Formations (Pennsylvanian)

The two formations are often considered as one section. The Belden is composed of dark shales and siltstones, and the Minturn is predominantly made up of red and green shales, siltstones, and occasional limestones. In aggregate, the two account for almost 5,000 feet of sediments.

There are no known references to fossils specifically attributed to the Minturn. There is brief mention of ostracods and brachiopods (Douglas and Peel 1972) in the sometimes recognized Sharpsdale Formation (pre-Minturn) in the Cotopaxi Inlier. The Sharpsdale is not mapped in the Inlier. The reference may pertain to Minturn rocks.

The Belden, on the other hand, is quite fossiliferous in the Wellsville area. Gwinn (1958) refers to an extensive list of marine invertebrates (Table 14) derived from the general district. Brachiopods are prominent members of the fauna. No elements are very extraordinary.

Sangre de Cristo Formation (Permian and Pennsylvanian)

Exhibiting a total thickness of up to 12,000 feet, the Sangre de Cristo forms large outcrop areas north of Howard, along Badger Creek, and south of the Arkansas River to nearly the southern end of the Sangre de Cristo Mountain Range. While a number of members have been proposed, there is generally a lower unit composed of red and green sandstones and siltstones similar to the Belden, and an upper unit much more conglomeratic than the lower.

A very interesting vertebrate fauna from the Sangre de Cristo is described by Vaughn (1969 and 1972) (Table 16). Elements of the fauna include: Elasmobranchs and Xenacanths, or fresh-water sharks; Labrinthodont amphibians - a water-dwelling Embolomere and rachitome Temnospondyls which may be terrestrials; Lepospondyls, including a snake-like Aistopod and a microsaur; the primitive "stem reptile" - Cotylosaurs, and some of the "mammal-like" reptiles - Pelycosaurs, including and Ophiacodont and a Sphenacodont as predaceous carnivores in the assemblage and a herbivorous Edaphosaurus.

Much of the fauna is new and others are known only on a much more regional basis. There is a good probability of making additional important discoveries; and given the expected low number of specimens obtainable, the formation areas are considered Class 1.

Plant fossils are also present in the Sangre de Cristo Formation. A collection made by White and reviewed in Douglas and Peel (1972) from the lower unit and near the portal of a Denver & Rio Grande Railroad tunnel along the Arkansas River (sec. 28, T49N, R10E) shows a fairly common flora (Table 15). Pollen has been obtained by Scott (1967) and Calamites are generally noted as being common throughout the upper unit.

Dry Union Formation (Pliocene - Miocene)

The Dry Union consists mostly of alluvial sands and gravels shed from adjacent mountain blocks during uplift in the Tertiary. Taylor, Scott, and Wobus (1975) make only an indirect reference to vertebrate fossils occurring in the formation. No other mention is found, but surely must exist.

The facies and environment of deposition exhibited by the formation is not readily conducive to good preservation. Vertebrate fossils apparently do exist in some regard, and in accordance, the formation is designated Class 2. However, based on additional detailed work, a Class 1 rating may be more appropriate.

FOSSIL FISH REMAINS - PARTING FORMATION & CHAFFEE FORMATION
PAMPE (1969)

Locality: Spring Gulch, SE¼, SW¼. Sec. 13, T49N, R9E, west side of the Arkansas River, approximately 0.6 miles southeast of the Chaffee - Fremont County line, and 3/4 mile northwest of Wellsville.

Collection from a red, siltstone-dolomite bed of the Parting Formation, 30.5 feet above the top of the Fremont Formation and 32.3 feet below the base of the Dyer Formation.

Placoderm fish: *Bothriolepsis* sp. cf. *B. coloradoensis*

Crossopterygian fish: *Holoptychius* sp. cf. *H. giganteus*

Holoptychius sp.

CHAFFEE FORMATION - BRYANT AND OTHERS (1936)

Locality: along Gribbles Creek, T51N, R11E, Fremont County, Colorado.

Collection from a light, yellow-grey, dolomitic sandstone 20 feet above the base of the Parting Member of the Chaffee Formation.

Crossopterygian fish: "related to" *Glyptopomus sayeri*

Elasmobranch fish: *Sandalous minor* Bryant
U.S.N.M. No. 13810 Holotype

Arthrodiran fish: "related to" *Aspidichtys*
U.S.N.M. No. 13819 specimen

Dinichthys tuberculatus
U.S.N.M. No. 13818 specimen

Dipnoan fish: *Dipterus johnsoni* Bryant
U.S.N.M. No. 13811 Holotype
" No.s 13813 and 13816 paratypes
" No. 13817 specimen

DEVONIAN FISH REMAINS - CHAFFEE FORMATION, FREMONT CO.
BRYANT AND OTHERS (1936)

LOCALITY: "along Gribbles Creek, T51N, R11E", in Fremont County, Colorado. Specimens are from "a light, yellow-grey, dolomitic sandstone" 20 feet above the base of the "Parting Member".

SPECIMENS:

A Crossopterygian fish similar to _Glyptopomus sayeri_

An Elasmobranch fish - _Sandalous minor_ Bryant (USNM 13810)

Arthrodiran fishes related to _Aspidichthys_ (USNM 13819) and to _Dinichthys tuberculatus_ (USNM 13818)

A Dipnoan fish - _Dipterus johnsoni_ Bryant (USNM 13811) and _paratypes_ (USNM 13813 and 13816). An additional specimen of the same is (USNM 13817).

REMARKS: This is the type locality for _Sandalous minor_ and _Dipterus johnsoni_ as designated by Byrant in Bryant and others (1936).

Table 14.

SPECIES LIST FROM THE BELDEN FORMATION - WELLSVILLE AREA
Gwinn (1958)

- *Juresania nebrascensis*
- *Sulcella sulcata*
- *Hastifaba spinosa*
- *Moorites minutus*
- *Sansabella carbonaria*
- *Endothyra* sp.
- *Jonesina* sp.
- *Microparaparchites* sp.
- *Amphissites* sp.
- *Spirifer occidentalis*
- *Schuchertella pratteni*
- *Pleurophorus occidentalis*
- *Spirifer rockymontanus*
- *Myalina* (*Myalinella*) *cuneiformis*
- *Nuculopsis ventricosa*
- *N. wewokana*
- *Pleurophorus subcostatus*
- *Neospirifer cameratus*
- *Schizophoria resupinoides*
- *Geisina jolliffina*
- *Crurithyris planoconvexa*
- *Aviculopinna americana*
- *Nuculana bellistriata*
- *Schizodus alpinus*
- *Yolida glabra*
- *Strobeus brevis*
- *Euphemites carbonarius*
- *Pseudorthoceras knoxense*
- *Edmondia meekiana*
- *Aviculopecten* ? sp.
- *Marginifera* cf. *wabashensis*
- *Orthotichia schuchertensis*
- *Tetrataxis* sp.
- *Composita subtilita*
- *Phricodothyris perplexa*
- *Orthotichia texana*
- *Dictyoclostus inflatus* var. *coloradoensis*
- *D. portlockianus*
- *Bythocypris* sp.
- *Cavellina pulchella*
- *Fabalicypris regularis*
- *Derbyia crassa*
- *Linoproductus* sp.
- *Bairdia seminalis*

Table 15.

SPECIES LIST - SANGRE DE CRISTO FORMATION

PLANTS: A collection of plant fossils made by White (1912?) near the portal of the Denver & Rio Grande Railroad tunnel - Section 28, T49N, R10E - from strata believed to be approximately 1300 feet above the base of the lower member.

Callipteris sp.

Psygmophyllum cf. cuneifolium

Odontopteris subcrinulata

Macrostachya? sp.

Sigillariostrobus nastatus

Walchia cf. piniformis

W. cf. imbricata

Rhabdocarpos dyaicus

Scott (1967) cites pollen from the lower member.

SE¼, SE¼, Sec. 18, T48N, R11E.

Bisaccate gymnospermous

Douglas and Peel (1972) note that species of Calamites are common throughout the upper member.

Table 16.

VERTEBRATES: Vaughn (1972)

- Elasmobranch fishes
- A xenacanth
- Palaeoniscoid fishes
- Labryinthodont amphibians
    - Anthracosurs
        - A large embolomere
    - Temnospondyls
        - Several small rachitomes including the dissorophid? - Amphibamus
- Lepospondyl amphibians
    - Aistopods
        - Coloraderpeton brilli Vaughn
    - Microsaurs
        - Trihecaton howardinus Vaughn
- Cotylosaurs
    - Desmatodon hesperis Vaughn

-continued-

SPECIES LIST - SANGRE DE CRISTO FORMATION - continued

Pelycosaurian reptiles
- A "medium-sized" ophiacodont
- A small sphenacodont
  - *Edaphosaurus* aff. *E. rayondi*
  - *E.* cf. *E. ecordi*

STRATIGRAPHIC SECTION FOR THE FRONT RANGE AND CANON CITY EMBAYMENT AREAS

Upper Cretaceous	Vermejo Formation	
	Trinidad Sandstone	
	Laramie Formation	
	Fox Hills Sandstone	
	Pierre Shale	
		Upper Transition Member
		Sharon Springs Member
		Apache Creek Sandstone Member
		Lower Transition Member
	Niobrara Formation	
		Smoky Hill Shale Member
		Fort Hays Limestone Member
	Carlile Shale	
		Juana Lopez Member
		Codell Sandstone Member
		Blue Hill Shale Member
		Fairport Chalky Shale Member
	Greenhorn Limestone	
		Bridge Creek Limestone Member
		Hartland Shale Member
		Lincoln Limestone Member
	Graneros Shale	
Lower Cretaceous	Dakota Sandstone	
	Purgatoire Formation	
Jurassic	Morrison Formation	
	Ralston Creek Formation	
	Entrada Sandstone	
Permian	Lykins Formation	
	Lyons Sandstone	

STRATIGRAPHIC SECTION FOR THE FRONT RANGE AND CANON CITY EMBAYMENT AREAS - continued

Permian – Penn.	Fountain Formation
Ordovician	Fremont Limestone
	Harding Sandstone
	Manitou Limestone
Cambrian	Peerless Dolomite
	Sawatch Sandstone
	Precambrian rocks

CANON CITY EMBAYMENT, GARDEN PARK, AND PARKDALE INLIER AREAS

Formations from Cambrian to Late Cretaceous in age outcrop in various portions of these adjacent areas. The Paleozoic rocks are largely confined to exposures on the northern margin of the Embayment and elsewhere where uplift has resulted in the truncated edge of the stratigraphic section. The central reaches of the Embayment and the southern portion of Garden Park contain mostly Cretaceous - aged strata. The Sawatch Sandstone and the Peerless Dolomite are not known to be fossil-bearing in this part of the study area.

Manitou Limestone (Lower Ordovician)

The Manitou in this region and elsewhere along the Front Range, contains a usually sparse marine invertebrate fauna essentially composed of trilobites, molluscs, crinoid stem fragments, and cystoids. Good localities exist north of Woodland Park, yet here are somewhat lacking. Flower (1952) names a new species of Plectoceras and cites the type locality (Table B). The formation has limited outcrop extent.

Harding Sandstone (Middle Ordovician)

Perhaps second only to the Morrison Formation, the Harding has received much acclaim due to the fact that it produces fossil remains of the oldest known vertebrates.

These primitive, jawless and armored fish (Ostracoderms) were first collected and described by Walcott (1892) at which time he named Eryptichius americanus and Astraspis desiderata, both from a locality a short distance west of Canon City. The dissarticulated plates or dermal armor of these Ostracoderms abound in some outcrops of the Harding, and sometimes even provide a recognition of the formation in the field. Even the most well-preserved specimens known and on which the descriptions have been made are at best greatly incomplete. There is a certain encouraging appeal that one might find a beautifully preserved and complete specimen. Such a discovery would be of extreme interest, undoubtedly shedding much light on these forebearers of all other vertebrates.

The facies exhibited by the Harding in the Canon City area are interpreted by Fischer (1978) as representing a predominantly estuarine, semi-alluvial environment of deposition. At a locality known as the Indian Springs Ranch (Table B) which now enjoys the benefits of landmark preservational status, a unique assemblage of arthropods, including merostomes, arachnids, and very large trilobites has been described - all on the basis of the remarkably well-preserved traces and trackways of the organisms (Fischer 1978)(Table B). The same general locality has apparently also produced perhaps the singlemost complete Ostracoderm body fossil, representing an anterior segment.

In addition to Ostracoderm and arthropod remains, the Harding contains numerous other invertebrates. Walcott (1892) and Sweet (1954) collectively, report an assemblage consisting mostly of molluscs and one brachiopod (Table B). Other work by Sweet (1955) concerns a large number of conodonts that are highly prevalent within the formation. The unit also produces its share of problematic fossils. Among these are *Dictyorhabdus priscus* (abundant in the Cotopaxi Inlier), a coiled form, and *Youngquistina mitteni*, a tooth-like form, apparently not a conodont and more likely an actual tooth structure (Jensen and Miller 1970).

Based on the foregoing, the Harding Formation in the Canon City area and vicinity is designated as Class 1, and continues as a primary subject of paleontologic study.

Fremont Limestone (Upper Ordovician)

Exposures of the Fremont, mostly thick-bedded carbonate sequences, occupy much of the same areas as does the Harding. Particularly good outcrops are noted in the northern reaches of Garden Park and in the quarries and small canyons due west of Canon City.

The Fremont is the single formation that contains only invertebrates and yet is considered as Class 1. The fossil material it contains has received very little study, and until such a time it has been fully described, it should be given a higher importance. It is however, not considered critical, and with future work, would more likely be assigned Class 2 status.

The only study of consequence is made by Sweet (1955) who reports a marine fauna dominated by ammonites with associated receptaculitids, cystoids and trilobites. Specimens are abundant; and altogether, the assemblage deserves additional work.

Fountain, Lyons, Entrada, and Ralston Creek Formations (Pennsylvanian through Upper Jurassic)

All of these formations outcrop in this portion of the study area, yet none have fossil occurrences attributed to them in these localities. Generally equivalent strata to the Fountain formation (Belden, Minturn, and Sangre de Cristo Formations) elsewhere in the area of the project have produced fossils. A member of the Fountain in the Colorado Springs area yields plant, as well as, common marine invertebrate material. The likelihood of finding fossils in the Fountain in this area is low but not impossible.

An as of yet to be described formation, seemingly between the Fountain and the Lyons Formations, is currently under study and has shown some evidence of vertebrates - possibly freshwater sharks - coming from a playa lake facies. The formation in question might eventually be recognized in the extreme northeastern area of the Embayment, and therefore in the study area (Hitchrack Ranch and Table Mountain areas).

Schoewe (1930), in abstract, makes an enigmatic reference to an undescribed fossil fish, reportedly from the Lyons Formation in Garden Park. No other information is found in support of his brief mention.

The Entrada Formation in the area is difficult to separate from the base of the overlying Morrison Formation. There is a certain low probability of finding fossils in the unit, as elsewhere on a regional basis, it has produced limited amounts. The Ralston Creek Formation is composed largely of evaporites and shales, and likewise is considered unlikely as a host for important fossils.

Morrison Formation (Upper Jurassic)

The Morrison Formation in the Canon City Embayment and Garden Park areas is typified by the variegated red and gray shales that are almost a hallmark of the formation over its entire extent. Other beds within the unit include thinly-bedded limestones and occasional channel sandstones. Alluvial and floodplain environments of deposition are suggested by the facies. Outcrops of the formation can be found along most of the northern margin of the Embayment and in the Parkdale Inlier. Particularly good and large exposures are prominent over much of the Garden Park region.

With its contained dinosaur fauna, the Morrison is probably more acclaimed than any other formation within the project area. Table 17 lists the different genera of dinosaurs reported from various localities in the Park. Many of these specimens are virtually complete and are displayed at the Yale Peabody, the Carnegie, the U.S.National, and the Denver Natural History Museums. A current excavation being conducted by the Denver Museum of Natural History, under the direction of Mr. Don Lindsey, is yielding a specimen of Camarasaurus with associated aligator teeth and turtle fragments. At least three additional sites in the immediate vicinity of the excavation are being considered by Lindsey for future work. (personal communication) Surface gathering commonly turns up many "rolled" bone fragments, teeth, and coprolites.

Perhaps as equally important as these enormous dinosaurs, are the extremely rare occurrences of tiny, early mammals. On the order of a small rodent in size, these little animals are highly significant as representatives of most early mammalian evolution. Pearl (1964) cites a lower jaw fragment of a Pantotherian as having come from Garden Park.

A very interesting molluscan fauna also occurs in the Morrison and contributes to the formation's notability. These fresh-water gastropods and bivalves are relatively unknown, yet might provide an important key to interpreting the paleoenvironments existing at that time.

Many specimens are fully silicified and are commonly found in the thin, lacustrine limestone beds. Table 18 is a composite list reported by Yen (1952) for locations in Garden Park, as well as, other portions of the study area. Along with the molluscs, ostracods and gyronites (reproductive structures of charephytes) both occur in abundance (Table 19). The only other mention of plant fossils in the Morrison is made by Berry (1933) and they more likely have come from the Cretaceous. Bonifide discoveries of plants in the Morrison would be important.

Because the Morrison produces such fine and complete vertebrates and that these occurrences are by nature rare, highly desirable by the general and not so general public, and easily destroyed; all outcrop areas of the Morrison Formation on BLM lands in the Canyon City Embayment and vicinity are considered Class 1. As to why the Garden Park region in particular is such a prolific dinosaur locality is yet to be fully explained. Large outcrop areas there are and have been easily available for exploration, whereas elsewhere, the formation is more obscure with less surface area exposed. There is a probability for making additional important discoveries in these areas that lie adjacent to Garden Park and exhibit much the same facies and conditions.

Purgatoire Formation and Dakota Sandstone (Lower Createous)

The Purgatoire and Dakota outcrop in each segment of the Canon City Embayment and related areas. The Purgatoire is somewhat conglomeratic at the base with mostly sandstones above. The Dakota has more variable lithologies, with occasional shales interbedded with even, fine-grained sandstones. Both are resistant to erosion and commonly form hogback or cuestas where they have been tilted.

Fossils are not known in the Purgatoire and there is little probability of finding important specimens. The Dakota in the area is only slightly fossiliferous. No reports are made, however, the formation elsewhere along the Front Range and further north has shown some vertebrate material including footprints and a few marine invertebrates. Mehl (1931) writes about some interesting bird tracks (Ignotornis) from a locality near Denver. Very fine plant fossils have been found, though most plant material is simply fragmental debris.

Graneros Shale and Greenhorn Limestone (Upper Cretaceous)

Outcrops of the Graneros and the Greenhorn fall primarily in the central and northerly portions of the Embayment. The units are represented by dark shales and alternating shale - limestone sequences, respectively. Both formations are highly fossiliferous with common marine invertebrate forms. Table 20 lists the ammonites that are abundant enough to be used for zonation within the units. Other aspects of the faunas include numerous Ostrea, or oysters, and other bivalves. Cobban and Scott (1972) make brief mention of fish scales and bones and allude to the presence of the shell-crushing ray, Ptychodus. Most of the fauna is common and well-known. Table 21 lists a typical assemblage of Foraminifera collected from various Front Range localities in the Graneros. Referenced U.S.Geological Survey Mesozoic localities are indexed in Table 22. Areas where these fossils are abundant on BLM land may provide locations for public collection of nicely preserved specimens.

Carlile Shale (Upper Cretaceous)

Component members of the Carlile consisting of an uppermost limestone and lower sandstones and shales often bear plentiful fossils. However, no occurrences are reported here. Regionally, the Codell Sandstone Member, in particular, renders a marine fauna containing much *Ostrea*, *Inoceramus*, and shark teeth. Burrows attributed to the shrimp, *Callianassa*, are quite common. Similar occurrences can be expected from the study area.

Niobrara Formation (Upper Cretaceous)

The Niobrara is another formation that often produces hogbacks in its physiographic appearance. The lower limestone member is generally erosion resistant in this arid climate. Much the same as the Carlile, the formation has produced faunas of consequence elsewhere, but not in the study area. The Niobrara of Kansas is notorious for its very fine marine reptiles. Along the Front Range, Inoceramid bivalves are dominant. Griffitts (1949) does describe a very curiously aberrant Rudistid bivalve, *Durania niobrarensis*, from eastern Colorado. The species is one of two ever found in the Western Interior. Coccolith microfossils abound in the limestones of the Smoky Hill Member (see Trexler 1962, 1967). Fossils should be collectable in the project area.

Pierre Shale (Upper Cretaceous)

The Pierre Shale is a formation that may provide an opportunity for public collection if a proper location can be selected. The formation is nearly 4,000 feet thick in the area and covers large areas in the central part of the Embayment.

Ammonites abound in these dark shales and are used to zone the formation (Scott and Cobban 1975)(Table 23). Contained in a certain zone within the formation are quasi-reef-like structures known as Tepee Buttes. These are nodular masses essentially composed of _Nymphalucina_ shells which weather out as conical mounds, effecting the appearance of indian tepees at a distance. Other elements of the Tepee Butte assemblage include various cephalopods, another bivalve, gastropods, and a few echinoderms (Table 24). Certain minute, root-like structures found in the Buttes suggest a sea grass bank origin for these features. Table 25 lists the referenced U. S. Geological Survey Mesozoic Localities for the Pierre in the Embayment area.

At least one large vertebrate has come from the Pierre. Scott (1969) reports a mosasaur, _Platecarpus_ cf. P. _crassartus_, from near Pueblo.

Fox Hills Sandstone = Trinidad Sandstone
Laramie Formation = Vermejo Formation (all Upper Cretaceous)

These formations which are generally correlative respectively across the Canon City Embayment exhibit facies corresponding to a regressive change in deposition from fully, open marine sediments (Pierre) to deltaic and fluvial deposits (Laramie = Vermejo). Most of the beds exposed in the central portion of the Embayment are mapped as Trinidad and Vermejo, yet fossils from the Fox Hills and Laramie are applicable.

Table 26 lists a common marine fauna as reported by Johnson (1928) from Fox Hills localities in Larimer County. Bivalves and gastropods dominate the collection. Fossil plants are common in the upper transitional beds (Table 27). Oman (1937) makes an interesting description of an insect he names Mesojassoides gigantea (Homoptera),based on some wing fragments discovered in eastern Colorado. Ophiomorpha, a type of diagnostic burrow, are prolific in most areas.

The Trinidad Formation in the Canon City area and regions to the south bears a nondescript marine fauna (Table 28). It is not known if the material is abundant. The Vermejo Formation contains extensive coal beds , much of which has been mined over the years in the Florence Field and Ratòn Basin. An interesting coalified footprint of a large vertebrate has come from the Chandler Coal Mine south of Canon City. The Vermejo is quite highly regarded for its fossil floras. The comprehensive study of Knowlton (1917) gives a lengthy list of plants from Canon City area localities (Table 29). Many of the specimens show exceptional preservation and are high in number.

None of the Cretaceous formations around Canon City and related areas contains or is predicted to contain fossils important enough to be considered Class 1. All of the formations, whether documented or not, can be assumed in some part, fossiliferous, and therefore, Class 2.

Table B Paleozoic fossil collecting localities within and adjacent to BLM Canon City District.

Location	Author-Reference	Formation-Geologic Age	Depository	Fossils
Harding Quarry or Sturbaum Quarry SW¼ sec. 31, T. 18S., R. 70W.	Walcott, Chas. D. (1892)	Harding-Ordovician	U.S. National Museum	Holotypes of *Eryptichius americanu* *Astraspis desiderata Dictyorhabdu* *priscus*
	Denison, Robert H. (1967, p. 140, fig. 1)	Harding-Ordovician	Field Museum	Only articulated specimen of *Eryptichius americanus*
	Flower, Rousseau (1952)	Harding-Ordovician	Paleontological Research Institute	*Kionoceras* sp. *Ormoceras pollacki*
Sec. 10, T. 16S., R. 67W. Sec. 1, T. 17S., R. 69W. Sec. 32, T. 17S., R. 69W. Sec. 33, T. 16S., R. 70W. Sec. 13, T. 18S., R. 71W. Sec. 31, T. 18S., R. 70W.	Sweet, Walter (1955, p. 226-262)	Harding-Ordovician	State University of Iowa	63 species representing 24 genera of conodonts
"north of Phantom Canyon Rd."	Flower Rousseau (1952)	Harding-Ordovician	Paleontological Research Institute	*Utoceras* cf. *gleneyriense*
Sec. 34, T. 16S., R. 69W.	Flower, Rousseau (1952)	Manitou-Ordovician	Paleontological Research Institute	Holotype of *Plectoceras manitouense*
NW¼ sec. 35, T. 17S., R. 69W.	Frederickson, E. A. & Pollard, J. (1952)	Harding-Ordovician	University of Oklahoma Geology Museum	Holotype of *Isalaux canonensis*
SE¼ sec. 33, T. 17S., R. 69W.	Frederickson, E. A. & Pollard, J. (1952)	Harding-Ordovician	University of Oklahoma Geology Museum	*Toernquistia* sp.
NE¼-NE¼ sec. 8, T. 18S., R. 69W. (Indian Springs Ranch)	Fischer, W. A. (1977, 1978)	Harding-Ordovician	University of Colorado Museum	Invertebrate and vertebrate trace fossils. Merostome body fossils *Astraspis desiderata* (articulated specimen)

Table B Page 2

Location	Author-Reference	Formation-Geologic Age	Depository	Fossils
"un-named tributary to Wilson Creek" Sec. 25, T. 17S., R. 71W.	Sweet, Walter (1955, p. 71-82)	Fremont-Ordovician	State University of Iowa	Lambeoceras sp. Endoceras sp. Actinoceras sp. Ephippiorthoceras sp.
Colorado Fuel & Iron Quarry, 2 mi. n.w. of Canon City	Sweet, Walter (1955, p. 71-82)	Fremont-Ordovician	Canon City Museum	Beloitoceras acculatum Probilingsites kessleri
Priest Canyon, 2 mi. n.w. of Canon City	Sweet, Walter (1955, p. 71-82)	Fremont-Ordovician	State University of Iowa	Allumetoceras sp. Ephippiorthoceras sp. Cyclendoceras cylindricum
S½ NW¼ sec. 13, T. 49N., R. 9E.	Sweet, Walter (1961)	Fremont-Ordovician	Reported from a measured section	Saffordophyllum Receptaculites Calapoecia Streptelasma
SE¼ SW¼ sec. 13, T. 49N., R. 9E. "Spring Gulch"	Pampe, William (1969)	Parting-Devonian	U.S. National Museum	Bothriolepis Holoptychus (placoderm and crossopterygian fish)
Garden Park--"9 miles north of Canon City"	Schoewe, Walter (1930)	Lykins-Permo-Triassic	Unknown--mentioned only as occurring	"1st fossil fish from the formation"
"roadside quarry exposure, along US 50 about 5.7 miles west of Canon City"	Miller, Halsey (1969)	Harding-Ordovician	Fort Hays Kansas State College Museum	Holotype of Youngquistina mitten
Sec. 27, T. 16S., R. 70W. Helena Canyon	Jensen, David & Miller, Halsey (1970)	Harding-Ordovician	University of Colorado Museum	2nd specimen of Youngquistina mitteni

FOSSIL VERTEBRATE OCCURRENCES - MORRISON FORMATION, GARDEN PARK REGION

Location: SE¼, SE¼, sec. 28, T17S, R70W. The Garden Park Dinosaur Monument (within a 2 mile radius of the Monument).

Reference: Brady (1969, p.632)
Original discoveries and descriptions by: Cope (1877, 1878); Marsh (1877, 1878); and Hatcher (1903 (2)).
All of these early discoveries are summarized by Hatcher (1901) and by Mook (1916).

Haplocanthosaurus
Camarasaurus
Amphicoelus
Allosaurus
Ceratosaurus

Additional cited by Pearl (1964)
Labrosaurus
Morosaurus
(*Brontosaurus*)
Coelurus
Laosaurus
Stegosaurus
Camptosaurus
Fish, turtles, and crocodiles

Location: NW¼, NW¼, sec. 34, T17S, R70W (ca. 2 miles from Mon.)

Reference: Specimen excavated in the late 1950's by the Cleveland Museum of Natural History.

Haplocanthosaurus

Location: sec. 26, T17S, R70W

Reference: Mr. Don Lindsey - current excavation - Denver Museum of Natural History

Camarasaurus
Aligator teeth and turtle fragments

MOLLUSCAN FAUNA - MORRISON FORMATION, GARDEN PARK & VICINITY YEN (1952)

Localities:

A.) Quarry Spur section, west end of Colorado Springs, ElPaso County, Colorado; U.S.G.S. Mesozoic Locality No. 5420.

B.) Lt. 38°31', Long. 104°52', Garden Park, Colorado; U.S.G.S. Mesozoic Locality No. 1325.

C.) West side of Penitentiary Ridge, 2 miles north of Canon City, Fremont County, Colorado. U.S.G.S. Mesozoic Locality No. 3211.

D.) Near Canon City. Fremont County, Colorado; U.S.G.S. Mesozoic Locality No. 481.

E.) Locality 8 miles north of Canon City, Fremont County, Colorado, known as the "bone yard"; U.S.G.S. Mesozoic Locality No. 397.

F.) Felch's Ranch, Garden Park, 9 miles north of Canon City, Fremont County, Colorado; U.S.G.S. Mesozoic Locality No. 17997.

G.) Fairplay - Como Road, just east of Red Hill Gap, about 4½ miles northeast of Fairplay, Park County, Colorado; U.S.G.S. Mesozoic Locality No. 6220.

Molluscs:

Unio felchi
U. toxonotus
U. macropisthus
U. iridoides
U. lapilloides

Amplovalvata cyclostoma
A. scabrida
Liratina jurassica
Viviparus morrisonensis
Mesauriculstra accelerata
M. morrisonensis
M. ovalis
Lymnaea ativuncula L. consortis
L. morrisonensis
Gyraulus veternus

(Abundant Ostracods)

PLANT FOSSILS - MORRISON FORMATION

Charophytes: (gyronites)

The described locality is Canon City, Sec. 19, T16S, R70W, and Red Hill, Sec. 25, T9S, R77W, Ross (1960).

Aclistochara bransoni
A. complanata
A. latisulcata
Obtusochara mädleri
Sellatochara obovata
Latochara latitruncata
Praechara voluta
P. symmetrica

The following plants have been described as being from the Morrison formation at its type locality. The collection is more likely from the Purgatoire or Dakota.

U.S.G.S. Localities No.s 7225 and 7225, Berry (1933) - near Morrison, Colorado.

Salix sp. cf. _Salix proteaefolia_
Ficus daphnogenoides
Ficus magnoliaefolia
Phyllites 2 spp.
Sapindopsis variabilis

Table 20.

SPECIES LIST - GRANEROS SHALE AND GREENHORN LIMESTONE
COBBAN AND SCOTT (1972)

Ammonites: (those abundant enough for zonation)

Graneros Shale

Calycoceras (Conlinoceras) gilberti

Acanthoceras granerosense

A. muldoonense

A. amphibolum

Greenhorn Limestone Formation

Lincoln Limestone Member

- *Acanthoceras amphibolum*
- *Calycoceras*? *canitaurium*

Hartland Shale Member

- *Metioceras* cf. *M. defordi*
- *Calycoceras*? sp.
- *Tarrantoceras*? sp.
- *Stomohamites*? sp.

Bridge Creek Limestone Member

- *Sciponoceras gracile*
- *Watinoceras coloradoense*
- *Mammites nodosoides*
- *Collingnoniceras woolgari*

Other Invertebrates:

Graneros Shale

Ostrea beloiti

Turrilites acutus americanus

Plicatula arenaria

Anomia sp.

Arrhoses modesta

Diploconcha? sp.

Nuculana? sp.

Wood and burrows

Breviarca? sp.

Exogyra sp.

Pecten (Camptonectes) cf.
P. cavanus

Limatula? sp.

Small pelecypods and gastropods

A solitary coral

Fish scales and bones

SPECIES LIST - GRANEROS SHALE AND GREENHORN LIMESTONE - cont.

Greenhorn Limestone

- _Inoceramus_ cf. _I_. _pictus_
- _I_. _labiatus_ var. _subhercynica_
- _I_. _rutherfordi_
- _Baculites_ cf. _B_. _yokoyamai_
- _B_. _calamus_
- _Anisomyon_ sp.
- _Puebloites_ sp.
- _Pteria_ sp.
- _Fagesia_
- _Holaster_ _feralis_
- _Camptonectes_
- Gastropods
  - the "shell-crushing ray" - _Ptychodus_

Table 21.

FORAMINIFERA SPECIES LIST - GRANEROS SHALE - FRONT RANGE LOCALITIES EICHER (1965)

Verneuilinoides perplexus *V. hectori*
Trochammina gatensis

Ammobaculites impexus
A. plummerae
A. mosbyensis
Trochammina wickendeni
Hedbergella delrioensis
H. planispira
Heterohelix golbulosa
Saccammina alexanderi
Pseudobolivina variana
Reophax pepperensis

Rotalipora greenhornensis
R. cf. *R. evoluta*
Globigerinelloides bentonensis
Praeglobotruncana stephani

Trochammina rutherfordi mellariolum
Textularia rioensis
Ammodiscus planus
Haplophragmoides gilberti *H. henderdonense*
Trochamminoides apricarius

Lenticulina gaultina
Praebulimina wyomingensis
Borissiakoceras compressum
Verneuilina canadensis *V. alameda*
Gaudryina spiritensis
Miliammina manitobensis *M. ischina*
Spirolocammina bowgheri

Table

Mesozoic invertebrate (predominantly Mollusca) fossil collecting localities in the Colorado Springs, Pueblo, Canon City vicinity, within and adjacent to BLM Canon City District.

Location	USGS Mesozoic Loc. No.	Formation and/or Member
NE¼ sec. 11, T. 16S, R. 67W.	15402	Bridge Creek Limestone Member of Greenhorn Limestone, Beds 67-97.
SW¼-SE¼ sec. 12, T. 17S., R. 67W.	22910	Bridge Creek Limestone Member of Greenhorn Limestone, Bed 97.
NE¼-SE¼ sec. 13, T. 17S., R. 67W.	22914	Bridge Creek Limestone Member of Greenhorn Limestone, Bed 97.
SE¼-SE¼ sec. 13, T. 17S., R. 67W.		Bridge Creek Limestone Member of Greenhorn Limestone,
	22915	Bed 67.
	22916	Bed 97.
NE¼-NW¼ sec. 30, T. 17S., R. 66W.	22919	Bridge Creek Limestone Member of Greenhorn Limestone, Bed 97.
W½ sec. 20, T. 18S., R. 70W.	5815	Bridge Creek Limestone Member of Greenhorn Limestone, Bed 97.
SE¼ sec. 21, T. 18S., R. 68W.	15394	Bridge Creek Limestone Member of Greenhorn Limestone, Bed 97.
SW¼-NW¼-NE¼ sec. 21, T. 18S., R. 68W.	D6571	5 ft. above base of Bridge Creek Limestone Member of Greenhorn Limestone, Bed 73.
SE¼-SW¼-SE¼-NE¼ sec. 21, T. 18S., R. 68W.	D6572	8 ft. above base of Bridge Creek Limestone Member of Greenhorn Limestone
SW¼ sec. 22, T. 18S., R. 68W.	D1308 D1309	2 ft. above base of Bridge Creek Limestone Member of Greenhorn Limestone, Bed 97.
Center SE¼-NE¼ sec. 18, T. 18S., R. 67W.	D5127	Second Limestone Bed above base of Bridge Creek Limestone Member of Greenhorn Limestone

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Location	USGS Mesozoic Loc. No.	Formation and/or Member
SW¼ sec. 20, T. 18S., R. 66W.	1311	Bridge Creek Limestone Member of Greenhorn Limestone, Bed 97.
Wild Horse Park sec. 2, T. 19S., R. 66W.	15393	Bridge Creek Limestone Member of Greenhorn Limestone, Beds 67-97.
NW¼-SE¼-SE¼ sec. 36, T. 20S., R. 66W.	D3966	Top of Graneros Shale
NE¼-SE¼-SE¼-SE¼ sec. 35, T. 20S., R. 66W.	D3984	Bridge Creek Limestone Member of Greenhorn Limestone, Bed 65.
NW¼ sec. 25, T. 20S., R. 66W.	D3986	Bridge Creek Limestone Member of Greenhorn Limestone, Bed 135.
SW¼-NE¼ sec. 25, T. 20S., R. 66W.	D4305	Bridge Creek Limestone Member of Greenhorn Limestone, Bed 105.
NE¼-SE¼-NW¼ sec. 25, T. 20S., R. 66W.	D4438 D4439	2½ ft. above base Bridge Creek Limestone Member of Greenhorn Limestone, Bed 97.
Rock Canyon Anticline NE¼-SW¼-NE¼ sec. 25, T. 20S., R. 66W		Bridge Creek Limestone Member of Greenhorn Limestone,
	D4440	Bed 97.
	D4441	Bed 101.
NE¼-SE¼-NW¼ sec. 25, T. 20S., R. 66W.		Bridge Creek Limestone Member of Greenhorn Limestone,
	D4442	Bed 105.
	D4443	Bed 113.
SW¼-SE¼-SE¼ sec. 35, T. 20S., R. 66W.	D6142	Bridge Creek Limestone Member of Greenhorn Limestone, Bed 90.
SE¼-SE¼ sec. 35, T. 20S., R. 66W.		Bridge Creek Limestone Member of Greenhorn Limestone,
	D6143	Bed 97.
	D6144	Bed 101.
	D6145	Bed 102.
SW¼-SE¼-SE¼ sec. 35, T. 20S., R. 66W.	D6146	Bridge Creek Limestone Member of Greenhorn Limestone, Bed 105.

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Location	USGS Mesozoic Loc. No.	Formation and/or Member
SW¼-NW¼ sec. 25, T. 20S., R. 66W.		Bridge Creek Limestone Member of Greenhorn Limestone,
	D6478	Bed 97.
	D6479	Bed 105.
	D6482	Bed 102.
NE¼-SW¼-NE¼ sec. 35, T. 20S., R. 66W.	D6486	Bridge Creek Limestone Member of Greenhorn Limestone, Bed 120.
SE¼-SW¼-SE¼ sec. 35, T. 20S., R. 66W.	D6487	Bridge Creek Limestone Member of Greenhorn Limestone, Bed 131.
NE¼-NE¼-NE¼ sec. 35, T. 20S., R. 66W.	D6535	Bed 105.
NE¼ sec. 34, T. 21S., R. 68W.	D3002	Thatcher Limestone Member
NW¼-NE¼ sec. 34, T. 21S., R. 68W.	D5708	Thatcher Limestone Member
NW¼-NE¼ sec. 34, T. 21S., R. 68W.	D5709 D5710 D5711 D5712	Graneros Shale at Various Intervals Above Thatcher Limestone Member.

SPECIES LIST - PIERRE SHALE - CANON CITY EMBAYMENT - continued

TEPEE BUTTE ASSEMBLAGE - PETTA AND GERHARD (1977)

Hoploscaphites sp.
Oxybeloceras sp.
Solenoceras sp.
Didymoceras sp.
Baculites sp.
Exiteloceras sp.
Inoceramus sp.
Nymphalucina occidentalis
Drepahochilus obesus
Graphidula cf. *G. alleni*
Echinocorys sp.
Foraminifera
Rhizomes

SCOTT (1969)

A Mosasaur from near Pueblo:

Platecarpus cf. *P. crassartus*

Table 25.

Mesozoic invertebrate (ammonite cephalopod) fossil collecting sites in the Late Cretaceous Pierre Shale of the Canon City-Florence Basin.

Location	USGS Mesozoic Loc. No.
SW¼ sec. 22, T. 19S., R. 69W.	D9053
NE¼ sec. 21, T. 19S., R. 69W.	D3006
SE¼ sec. 17, T. 19S., R. 69W.	D8737
NW¼ sec. 15, T. 19S., R. 69W.	D8696 D8697 D8698
E½ sec. 15, T. 19S., R. 69W.	D8822 D8823 D7996 D8005 D8694 D8693 D8695
SW¼ sec. 11, T. 19S., R. 69W.	D8692
NE¼ sec. 10, T. 19S., R. 69W.	D8691
NW¼ sec. 9, T. 19S., R. 69W.	D8700
SW¼ sec. 8, T. 19S., R. 69W.	D3019
SW¼ sec. 3, T. 19S., R. 69W.	D8689
SE¼ sec. 4, T. 19S., R. 69W.	D8699
NW¼ sec. 33 T. 18S., R. 69W.	D8000 D8820 D8821
NE¼ sec. 32, T. 18S., R. 69W.	D8755
NW¼ sec. 1, T. 20S., R. 69W.	D8591
NW¼ sec. 2, T. 20S., R. 69W.	D8606
S½ sec. 3, T. 20S., R. 69W.	D8604 D8605 D8585 D8571
NW¼ sec. 3, T. 20S., R. 69W.	D8580

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Location	USGS Mesozoic Loc. No.
SW¼ sec. 4, T. 20S., R. 69W.	D8570
	D8824
SW¼ sec. 35, T. 19S., R. 69W.	D8607
	D8597
	D8590
	D8578
NE¼ sec. 35, T. 19S., R. 69W.	D8598
	D8581
	D8583
	D8575
	D8595
	D8596
	D3011
	D3012
	D3013
NE¼-SW¼ sec. 26, T. 19S., R. 69W.	D3008
	D3009
	D3010
NW¼-NE¼ sec. 27, T. 19S., R. 69W.	D3007
NE¼-NE¼ sec. 28, T. 19S., R. 69W.	D8579
SE¼ sec. 29, T. 19S., R. 69W.	D7999
N½ sec. 31, T. 18S., R. 69W.	D8752
	D8753
	D8751
	D8756
	D8757
	D8750
	D8754
	D8749
sec. 28, T. 18S., R. 69W.	D8813
	D8814
	D8815
	D8816
	D8685
	D8686
	D7995
	D9056
	D9052
	D8817
	D8004
	D8687

Location	USGS Mesozoic Loc. No.
sec. 28, T. 18S., R. 69W.--continued	D8818
	D8003
	D8688
	D8819
	D8006
	D8001
S½ sec. 21, T. 18S., R. 69W.	D8809
	D8002
	D8684
	D8810
	D8811
	D8812
	D7998
	D3015
SW¼ sec. 10, T. 18S., R. 70W.	D1988
	D1989
	D4849
S½ sec. 9, T. 18S., R. 70W.	D4848
	D4850
	D4847
	D4851
	D4852
	D4845
	D2695
NW¼ sec. 16, T. 18S., R. 70W.	D8747
	D8748
SW¼ sec. 16, T. 18S., R. 70W.	D8746
	D8745
SE¼ sec. 17, T. 18S., R. 70W.	D8759
NW¼ sec. 21, T. 18S., R. 70W.	D8743
	D8744
	D8761
SW¼ sec. 22, T. 18S., R. 70W.	D8742
NW¼ sec. 5, T. 19S., R. 70W.	D8762
SW¼ sec. 5, T. 19S., R. 70W.	D8825
SE¼ sec. 7, T. 19S., R. 70W.	D8703

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Location	USGS Mesozoic Loc. No.
S½ sec. 17, T. 19S., R. 70W.	D8739 D8738 6569 D8764
NW¼ sec. 21, T. 19S., R. 70W.	D8763
N½ sec. 3, T. 20S., R. 70W.	D8713 D8714 D8716
NE¼ sec. 4, T. 20S., R. 70W.	D8709
N½ sec. 10, T. 20S., R. 70W.	D8710 D8712 D8715 D8711

Table 26.

INVERTEBRATES - FOX HILLS FORMATION, LARIMER CO., COLORADO
JOHNSON (1928)

Bivalvia: *Callista nebraskensis*
Cardium speciosum
Gervillia subtortuosa
Mactra formosa
Modiola meeki
Nucula larimerensis
N. weldensis
Ostrea gillulyi
O. sp.?
Protocardia subquadrata
Pteria nebrascana
Teredo? tubes
Veniella humilis

Scaphopoda: *Dentalium gracile*

Gastropoda: *Anchura americana* (*A. forresteri* in Reeside 1928)
Cylichna volvaria
Fasciolaria (*Piestocheilus*) *scarboroughi*
F. sp.
Fusus sp.
Grodes johnsoni
Maminea subcylindrica
Lunatia occidentalis
L. subcrassa
Pyropsis bairdi
P. sp.
Trachytriton vinculum

Cephalopoda: *Discoscaphites conradi*

In addition to invertebrate remains, shark teeth, small vertebrae of fish, and silicified wood have been noted.

FOSSIL PLANTS - FOX HILLS FORMATION, THE COLGATE MEMBER FROM LOCALITIES IN WYOMING AND MONTANA BROWN (1939)

Asplenium tenellum
Nilssonia gibbsii
Ginkgo laramiensis
Sequoia magnifolia
S. reichenbachi
Podocarpus? stantoni
Cephalotaxus? coloradensis
Thuja colgatensis
Pistia corrugata
Myrica torreyi
Dryophyllum subfalcatum
Ficus speciosissma
Aristolochia? coloradensis
Cinnamomum affine
Laurus lanceolata
Nelumbo dawsoni
Paranymphaea hastata
Magnolia lakesii
M. nervosa
Lissites colgatensis
Vitis stantoni
Rhamnus? willardi
Lornus praeimpressa
Diospyros berryana
Dombeyopsis colgatensis
Phyllites cockerelli
Halymenites major

KNOWLTON (1916) collection made from Wildcat Mound located approximately 2½ miles north of Miliken, Colorado.

not named above:

Anemia sp.
Equisetum sp.
Viburnum vulpinum

NOTE: *Halymenites major* is the most frequently occurring plant fossil in the formation.

(28) SPECIES LIST - TRINIDAD SANDSTONE LEE AND KNOWLTON (1917)

Invertebrates: Canon City area

Anomia?
Avicula nebrascana
Chlamys nebrascensis
Inoceramus barabini
I. Sagensis
Lugumen?
Mactra sp.
Mytilus? sp.
Ostrea pellucida
Panopaeae?
Tancridia americana
Tellina scitula
Tellina sp.

Fish bones and scales
the plant - *Halymenites*

(29) PLANT FOSSILS VERMEJO FORMATION (sec.s 13, 25, 17, 36, T19S, R70W, sec.s 18, 30, 31, T19S, R69W, sec.s 18, 30, T20S, R69W)

Halymenites major
Acrostichum haddeni
Polystichum hillsianum
Pteris russellii, *P. erosa*
Asplenium? *coloradoense*
Stenopteris? *cretacaea*
Osmunda hollicki
Gleichenia rhombifolia
G. delicatula?
Anemia robusta
A. supercretacea
Sequoia reichenbachi
S. obovata
Cupressinoxylon coloradense
C.? *vermejoensis*
Sabal montana
Canna magnifolia
Juglans coloradensis
J. similis
Myrica torreyi, *M. coriacea*
Salix plicata
Quercus rockvalensis
Laurus coloradensis
Platanus? sp.
Amelanchier obovata
Phaseolites crassus. *P. leei*
Celastrus haddeni
C. hesperius
Rhamnus salicifolius
Pterospermites wardi
Viburnum montanum
V. problematicum
V. simile
Paleoaster inquirenda
Phyllites protophylloides
P. castalioides

species of *Ficus*- *dalmatia*,
haddeni, *eucalyptifolius*, *leei*,
newberryana, *praetrinervis*,
regularis, *rhamnoides*,
rockvalensis, *speciosissima*,
tessellata, *wardii* , *cuta*.

RECOMMENDATIONS FOR THE MANAGEMENT OF FOSSIL RESOURCES

All fossils at the surface are subject to loss. Natural erosional forces cetrainly destroy numerous good specimens, however, erosion is also responsible for exposing fossils in the first place. The incursions of man's activities, on the other hand, can often lead to serious losses of critical material.

A certain paradox exists where some construction oriented projects actually provide far better exposures than naturally exist. Undeniably, roadcuts are almost universally regarded as some of the best locations for study. Historically, excavations for buildings and in mining have lead to important discoveries.

Considering multiple uses of BLM lands, all possible uses can be allowed on Class 3 lands in regard to their lack of fossils. Similarly, there is little likelihood of serious impact being caused by all activities on lands designated as Class 2. Certain usage of Class 1 lands, however, might result in fossils of high scientific interest being destroyed or lost.

Grazing, by example, probably cannot seriously effect fossils. Rare cases might be imagined where a vertebrate specimen is weathering out at the surface and a high density of animals in a small area or on a trail could do damage.

The same may be true for heavy off-road vehicular travel which could be more damaging. As indicated above, various excavations can lead to discoveries, but certainly can account for substantial losses of fossils. Water impoundment is perhaps the singlemost detrimental usage that can be conceived as having a strongly negative impact. Large-scale surface construction and development might also be included where critical outcrop areas are effectively removed from study.

The best recommendation that can be made is to undertake detailed field work in those Class 1 areas that show any signs of serious conflicts and then to simply judge each project on its own merits, weighing these against the benefits derived from preserving or salvaging unique fossil material.

Many Class 2 portions of the study area may provide opportunities for public collecting of fossils. To designate such an area, it should be selected on the basis of adequate access and fossil abundance and quality of preservation, to make efforts worthwhile. Interested, amateur collectors would probably make the most use of a public area, doing so responsibly. However, the interest of the general public in silicified wood, for instance, should not be underestimated, and allusions to abundant "petrified wood" for the taking should be avoided.

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SPECIES LIST - PIERRE SHALE - CANON CITY EMBAYMENT
SCOTT AND COBBAN (1975)

Ammonite zones:

(top)

- Baculites eliasi
- B. jenseni
- B. reesidei
- B. compressus
- Didymoceras cheyennense
- Exiteloceras jenneyi
- Didymoceras stevensoni
- Didymoceras nebrascense
- Baculites scotti
- B. gregoryensis
- B. perplexus
- B. asperiformis
- B. maclearni
- B. obtusus

(bottom)

Other Invertebrates:

species of Inoceramus - simpsoni, aff. cycloides, agdjakendensis, subcompressus, proximus, convexus, sublaevis, tenuilineatus, saskatchewanensis, pertenuis, barabini, nebrascensis, cf. vanuxemi, typicus, subcircularis, oblongus.

- Ostrea inornata
- O. plumosa
- Anapachydiscus complexus
- Munuites sp.
- Phelopteria linguaeformis
- Haploscaphites gilli
- H. nodosus
- Solenoceras sp.
- Placenticeras meeki
- Eutrophoceras sp.
- Nostoceras sp.
- Exiteloceras oronense
- Cymbophora holmesi
- C. canonensis
- Capulus spangleri
- Anisomyon subovatus
- Baculites crickmayi
- B. rugosus
- B. undatus?
- B. claviformis
- B. clinolobatus
- B. grandis
- B. baculus
- fish parts and plant fragments

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